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TRANSLATION

METHOD AND DEVICE FOR THE COOLING OF BLOWING LANCES

The invention relates to a method of cooling blowing lances which are used in the treatment of liquid metal melts in metallurgical vessels and especially and optionally in vacuum-treated steel in a RH [Ruhrstahl-Heraeus] vessel and/or for the heating of metal melts (optionally under vacuum) by means of a lift device in the interior of the vessel and which can be raised and lowered, the blowing lance having at least one inner guide tube for feeding gases, especially oxygen, having a head-end lance mouth for the blowing of the gas and to the metal melt, and which also has a cooling jacket extending over its entire length for traversal by a cooling medium and which is formed as a double-wall jacket tube has an inner cooling passage and an outer cooling vessel and a rerouting tube in the region of the head end, whereby the metallurgical vessel is connected with a vacuum pump to reduce the pressure therein.

The invention relates further to a device for carrying out the aforementioned method with a metallurgical vessel in which a blowing lance can be inserted into the interior of the vessel and withdrawn by means of a lifting device and in which the blowing

lance has at least an inner guide tube with a head-end lance mouth and a cooling jacket and wherein the cooling jacket is comprised of an inner cooling passage and an outer cooling passage which are connected by a rerouting tube and wherein the metallurgical vessel can be evacuated by a pump connected by a vacuum fitting to the metallurgical vessel.

Blowing lances of the aforedescribed type are basically known in the state of the art. The cooling medium is usually water and flushes through the lance in a large volume rate of flow under pressure to the lance head during the blowing of gases or solids onto the steel melt. Especially at the end of the lance head burn spots on the surface of the bath radiate toward the lens head and produce extremely high temperatures which bring about a general increase in wear or crack formation in the lance head as a consequence of which the wall thickness of the cooling chambers formed in the lance head become thinner with time, soften and which suffer rupture. Escaping water can then evaporate, overwhelm the suction capacity of the vacuum pump and create excessively high pressures in the vessel.

To avoid on the one hand the danger of water breakthrough in the operation of a blowing lance and on the other hand to cool the lance internally, in another process in which the blowing lance is immersed in the melt, as proposed in DE 35 43 836 C2, two alternately used blow lances are employ d which can be cooled with

cooling water. Of the two blowing lances, only the one which is in the blowing position at any point in time and is immersed in the melt is cooled with air while the one outside the melt at any point in time is cooled intensively with the cooling water. The alternating use of two blowing lances is however comparatively extensive. For a water-cooled blowing lances, therefore, it is proposed in DE 35 43 836 C2 that the temperature detected by temperature sensors in heat-conducting contact with the wall of the lance head be used to control the water cooling and/or the oxygen feed and/or the feed of additive substances and/or the spacing of the lance head from the melt bath.

The drawback connected with the water cooling of blowing lances, namely that in the case of a defect arising in the region of the cooling jacket of the lance (rupture or crack) and the associated entry of water into the vessel above the hot molten metal in the vessel and the reaction space thereabove to a shock-like and rapid expansion of the liberated water turning into steam and a possible splitting of hydrogen gas from the water vapor has not been eliminated heretofore. Especially in the case of RH vessels which only have a limited free space in the vessel, there is a significant danger where the internal temperature of the vessel can reach up to 1800°C. The cooling water circulating through the lance at a flow rate of 30 m^3/h to 50 m^3/h upon conversion to steam can only be drawn off to a limited extent by the vacuum pumps utilized in state of the art systems because with

the cooling water quantities of this magnitude, the ratio of the suction rate to the steam quantity produced in the case of breakthrough can amount to 1:20 to 1:100.

From an apparatus viewpoint, in the RH vessel, the two immersion or riser tubes [syphon tubes] which extend into the molten steel form a syphon-like closure which, since the incorporation of pressure relief openings (expansion flaps) is not possible, serves as a single pressure equalization opening under the circumstances. When unfavorable circumstances concatenate in the case of a water breakthrough through a defect in an oxygen lance into a RH vessel, the following expansion can reach an expansion final pressure of about 14×10^5 Pa. At the expansion speed of 2×10^7 Pa/s and pressure relief only through the syphon tubes, large quantities of molten steel can be forcibly thrown into the region surrounding the apparatus.

It is the object of the present invention to develop a method of the type mentioned at the outset further so that in case of a cooling jacket leak form the lance, the aforedescribed drawback is limited, the safety of operating personnel is increased and the entire apparatus is made more secure. The same applies also in the case of the improved apparatus.

The objects set forth are achieved by the method according to claim 1. The first feature thereof is the use as

cooling medium of a gas whereby in the case of a defect in the lance in a quantity of cooling medium which is released can then be drastically reduced. Calculations which have been made have shown that with oxygen-blowing processes under a pressure of 1×10^4 to 2×10^4 Pa in a RH vessel a cooling steam throughput of 1000 kg/h will suffice and with a VCD operation under a pressure 70 Pa to 4×10^3 Pa, a coolant steam throughput of 360 kg/h will suffice. This quantity of steam is greatly reduced by comparison with that which can be evolved by water cooling and can readily be sucked off without special techniques in the case of a crack in the lance or a rupture of the lance by the suction pump without creating a dangerous expansion within the vessel. The ratio of the suction capacity of the (vacuum) pump to the quantity of steam utilized amounts to about 2:1 to 6:1 so that steam development with expansion through the syphon tube is effectively avoided. A further feature of the invention resides in that the intensively available suction capacity of the pump controls the flow rate of the gases used s a cooling medium. If the suction capacity of the pump falls or is smaller or small for other reasons, the cooling gas flow is correspondingly minimized so that a sufficient ratio of the suction capacity of the pump to the cooling gas quantity which must be drawn off in the case of a failure will remain at $\geq$ 1.

Further developments are described in claims 2 to 8.

In accordance with a further development of this method, the instantaneously available pump suction rate additionally controls the lance feed whereby preferably with a measured difference between the quantity feed for lance cooling of the quantity of gases lead away from the lance controls, the lance feed can directly terminate the gas feed. The first feature serves to prevent further damage to the lance by a sharp temperature increase as the lance approaches the surface of the bath. The other feature ensures that only the quantity of gas which at the time is in the cooling jacket of the lance can flow out.

Preferably superheated steam is used as the cooling medium, especially superheated steam heated to 20°C above the boiling point of water. For cooling with steam, the volume flow rate will correspond to any other cooling as used in accordance with the state of the art, especially nitrogen or argon. Because of the small volume flow rate which is required for cooling, the widths of the cooling passages can be minimized.

According to a further feature of the invention, during the oxygen blowing, the cooling medium is admitted into the inner cooling channel or passage and is lead out through the outer cooling channel or passage. This ensures that directly in conjunction with the greatest heat pickup, the superheated steam which is fed into the lance is led directly out of the lance in the region of the outer cooling channel or passage. In addition, the

lance has the advantage that the oxygen fed through the inner guide tube is heated by the steam quantity which flows along the inner guide tube and thus is blown into the steel melt in the vessel already in the heated-up state. As a result, there is a reduced temperature loss in the molten steel, a more intensive carbon reaction in the oxygen blowing decarbonization, a more intensive aluminum reaction with chemical heating as well as an improved oxygen efficiency or utilization, and finally a reduced oxygen consumption.

For the case in which the lance, between suction phases in VCD operation is located in an upper parked position, it is further provided that the steam is fed through the outer cooling passage or channel of the cooling jacket and after rerouting at the heat end, is led off through the inner cooling channel or passage. To the extent the ambient temperature of the lance is in this case smaller than with oxygen blowing operations, the steam supply to the cooling jacket ensures that the steam will initially heat up the region of the outer cooling channel or passage so that the cooling down of the steam and the formation of the condensate as a result can be avoided in the region of the cooling channels or passages.

To avoid an overheating of the cooling jacket and to optimize the quantity of the cooling medium required for the diff rent lance passages and operating conditions, a further

feature of the intention provides that the quantity of the cooling medium admitted to the cooling jacket, namely the water vapor or steam, is controlled in dependence upon the temperature measured at the outer jacket of the lance and/or the instantaneous lance position. To avoid a condensate formation from arising in the head region of the lance, the lance is preheated in startup of its operation initially without cooling and in that the lance is fed into the already heated metallurgical vessel and only thereafter is the steam cooling switched off.

In the use of steam, it is preferably supplied under a pressure of at least 7 x 10^5 Pa at a temperature of 160°C to 210°C as the coolant.

The objects are further attained with a device according to claim 9 which, according to the invention, includes a control unit for adjusting the throughflow of the gas serving as the cooling medium as a function of the instantaneous lance position, the suction power of the vacuum pump which is available and the outer wall temperature of the lance. Preferably via the control unit the lance feed is also adjusted.

An improved heat abstraction can be ensured when the inner surface of the outer cooling jacket tube turned toward the cooling passage has radially projecting ribs in the cooling passage or channel.

Preferably the mouth of the lance is configured as a Laval nozzle.

Further advantages of the invention as well as examples are illustrated in the drawing. It shows:

FIG. 1 a schematic cross sectional view of a blowing lance,

FIG. 2 the lance according to FIG. 1 in a section along line II-II in FIG. 1,

FIG. 3 a cross sectional view of a RH vessel with the lance introduced and including in a schematic illustration the controlled unit,

FIGS. 4 to 7 respective cross sections of RH vessels with different lance positions or in different operating states and

FIGS. 8 to 11 respective time-temperature diagrams of the temperatures calculated according to FIGS. 4-7 under process conditions.

The lance 10 which is basically known from the state of the art, comprises an inner guide tube 11 which at its head end terminates in a nozzle 20, preferably a Laval nozzle open at the

lance mouth 12. Through this guide tube a gas, especially oxygen, can be fed. The guide tube 11 is surrounded by cooling jacket 13 with an outer tubular cooling jacket tube 13a whose internal space is subdivided by an inserted rerouting tube 14 into an inner cooling channel or passage 15 surrounding the inner guide tube 11 and into an outer cooling passage or channel 16. The rerouting tube 14 reaches into the head region of the lance 10 but terminates before the nozzle 20 so that a rerouting region 17 is formed as the connection between the inner cooling passage 15 and the outer cooling passage 16. Each of the two cooling passages 15 and 16 is connected at the foot end of the lance with respective openings 18 which can be switched over, depending upon the desired cooling medium flow direction between an inlet and an outlet.

As FIG. 2 shows, for improvement of the heat transfer to the cooling medium traversing the cooling jacket, the surface of the outer cooling jacket tube 13a turned toward the cooling channel 16 is formed with ribs 19 projecting radially into the cooling channel 16.

To cool the lance in its possible operating states, as will be described in greater detail subsequently, a cooling gas, preferably 20°C to 50°C superheated steam is fed through the cooling passages 15 and 16 of the cooling jacket 13. To avoid condensate formation in the cooling channel of the cooling jacket of the lanc , a cross switching can be provided for the inlet and

outlet of the steam between the inner cooling passage 15 and the outer cooling passage 16. Thus for example with higher thermal loading of the lance during oxygen blowing operations, the feed fo the cooling steam is effected through the opening 18 connected with the inner cooling passage 15 so that the steam will initially flow along the inner guide tube 11 to the rerouting region 17 of the cooling jacket 13 and from here out through the outer cooling passage 16 which is in contact in the tubular jacket 13 with the lance surrounding reaction space of the vessel. If however the lance is in its upper parked position between treatment phases of individual charges, there is a significantly reduced heat effect upon the outer cooling jacket 13. In this case the steam is initially blown into the outer cooling passage 16. The steam is discharged through the inner cooling channel and its head side discharge opening 18. A corresponding flow applies in the case of VCD operation.

The same applies to start-up operations, that is when the lance is cold and when the lance 10, initially without steam cooling is fed into the vessel 200 to heat up the lance. The same cooling flow is then switched over only after preheating of the lance.

As can be seen in greater detail from FIG. 3, a metallurgical vessel 200 can have its immersion or dip tubes or syphon tube. 21 inserted in the m tal melt 29 filling a ladl 23.

The treatment vessel 200 is evacuatable by means of a pump 30 through a connecting fitting 22. The pump 30 and the lance drive 24 are connected with a control unit 27. To determine the instantaneous lance position, an encoder 25 is provided.

In addition, along the lance jacket with different longitudinal axial spacings from one another and at the lance mouth, temperature sensors are provided of which only the temperature sensor 26 has been shown in FIG. 3. The temperature measured at this sensor and the other temperature seniors are supplied to the control unit 27. The control unit 27 controls the cooling gas quantity fed to the jacket through a controller 28 as a function of the suction capacity of the pump 30 and the temperatures measured by the temperature sensors. A flow rate measuring device, not shown in detail, can be provided which can detect the rate at which the cooling steam is supplied and any deviation can serve as an indication that a leak may be present, transmitting a signal to the control unit 27. In the case of leakage, the further cooling gas supply as well as the lance feed are terminated or a withdrawal of the lance from the vessel 200 is triggered.

FIG. 4 shows a lance inserted into the vessel 200. In the illustrated state, standard or normal pressure prevails in the interior of the vessel, that is the pump 30 is not in operation. Neither the guide tube 11 nor the cooling gas passages 15 and 16

are yet supplied with gas. These assumptions in a concrete application, a temperature T_i of 1500°C prevails in the interior space of the vessel. The temperatures T_1, T_2, T_3, and T_4 measured on the lance within the first two minutes have been shown in FIG. 8. In the concrete application at the head of the lance, a temperature increase to 1060°C can be measured. After two minutes, the steam coolant is switched on and steam at a temperature of 160°C and a pressure of 7×10^5 Pa is supplied. The temperatures T_1 and T_2 measured at the lance head drop to 260°C and 215°C. The quantity of steam fed through the cooling passages 15 and 16 then amounts to about 179 kg/h.

FIG. 5 shows the lance 10 in an oxygen-blowing operation. Within the interior of the vessel a pressure of 2×10^4 Pa and a temperature T_i of 1800°C prevails. Through the guide tube 11 oxygen is blown onto the mouth in an amount of for example 1000 standard Nm^3/h. In lance cooling, steam at a pressure of 7×10^5 Pa at a temperature of 160°C is used. The course of the temperature T_1, T_2, T_3, T_4 and the steam outlet temperature are given in FIG. 9.

FIG. 6 shows a lance which has been fed into the vessel 200 in a VCD process, that is without oxygen fed through the guide tube 11. The pressure adjusted within the interior of the vessel lies between 70 Pa and 4×10^3 Pa. The lance is cooled with steam (7×10^5 Pa, 160°C). The internal temperature T_1 within the vessel amounted to 1200°C. The quantity of steam traversing cooling

passages 15 and 16 amounted to 360 kg/h. The course of the temperatures T_1 to T_4 and the steam discharge temperature T_{Da} can be seen from FIG. 10. The amount of steam passing through was 360 kg/h.

FIG. 7 shows the lance in an upper park position. The vessel 200 has its syphon tubes immersed in the melt. As can be seen from FIG. 11, the measured lance temperatures indicate over a short period of time from 20°C to 160°C or 200°C while the steam throughput amounts to 1464 kg/h.

The respective described and investigated operating situations show that with an oxygen blow process, operating under a pressure of 0.5×10^4 to 2×10^4 Pa, a steam coolant throughput of 1000 kg/h and in a VCD operation under a vacuum of 70 Pa to 4×10^3 Pa can have a steam coolant throughput of 360 kg/h. By comparison to a liquid water cooling significantly less steam volumes are used and those which can be generated in the case of lance cracks or rupture and which cannot be drawn off by the vacuum pump safely, that is without creating a dangerous expansion within the vessel 200.

A differential measurement between the admitted quantity of steam and the discharge quantify of stem by flow and pressure measures I the supply and discharge lines indicates immediately any lanc l akage. Advantageously to avoid condensate formation in an

upper position of the lance, the steam flow direction is reversed by corresponding switchover of the valves.